DYNAMICAL DELOCALIZATION IN A COHERENTLY TIME-VARYING ONE-DIMENSIONAL DISORDERED SYSTEM

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There are many theoretical and experimental studies on quantum diffusion in dynamically fluctuating media[1]. In these studies, stochastic Hamiltonian, in which the stochastic variables obey a Gaussian-white or Gaussian-Markoffian process describing an effect of incoherent lattice vibrations due to the thermal fluctuation, have been so far used.

In this report, we deal with a tight-binding single band one-dimensional disordered system (1-DDS) with the coherently time-varying on-site energies as follows;

$$H(t) = \sum |n\rangle V(n,t) \langle n| + \sum K(n,m)(|n\rangle\langle m| + |m\rangle\langle n|),$$

where the set of the basis $\{|n\rangle\}$ is an orthonormalized one and $V(n,t)=V_0(n)+ 1/\sqrt{M}\ \Sigma V_i(n)\varepsilon_i\cos(\omega_i t)$, where the $V_i(n)$ is a random atomic energy at site n varies at random uniformly in the range [-W,W], and all the off diagonal energies take a fixed value $K(n,m)=-\delta_{m,n\pm1}$.

It is important to stress that this model does not contain any stochastic time-varying perturbation but does a coherently varying one. In addition, it is worth noting that the perturbation is added to localized state in this model, which is quite different from the case $V_0(n)=0$[2].

It is well-known that time evolution of a wave packet is suppressed owing to the Anderson localization in the static case($\varepsilon_i=0$)[3]. And dynamical localization in the momentum space also occurs in the kicked rotator as a result of the quantum interference effect[4]. On the other hand, it has been shown that the dynamical localization is broken down under an application of very weak external noise or a very weak coupling among another quantum kicked rotor[4].

We are concerned with whether and how the dynamical perturbation from other finite degrees of freedom can destroy Anderson localization in intrinsic random systems. As a first step of the study, we investigate numerically the delocalization in the 1-DDS containing only a coherently time-varying diagonal energy.

Figure 1 shows the time-dependence of mean square displacement (MSD) $\langle\langle n(t)^2\rangle\rangle = \Sigma\, n^2 \langle|\phi_n(t)|^2\rangle$ of the wave packet for the case of various parameter with multiple colors. It seems that the diffusion of a wave packet behave like an anomalus diffusion, $\langle n^2\rangle \approx Dt^\alpha$ from the long-time numerical data. The estimated exponent a for various parameters are plotted in Fig.2. It is found that the exponent approach to one corresponding to normal diffusion asymptotically as the number of color increase. Although the each form of MSD is depend on some parameters, for example, perturbation strength and frequencies and so on, the qualitative behavior is not changed. Those results is also consistent with a numerical results in 1-DDS directly coupled with linear oscillator[5].

A diffusion motion which implies an appearance of irreversibility is realized in our simple system. Traditional theory of electron transport has supposed that the electron system is interacting with phonon field with infinite number of degree of freedom, and the origin of finite resistivity that suggests irreversibility or dissipation has been attributed to infiniteness of the number of phonon modes. Our results suggest that even 1-DDS is very sensitive to the interaction with other degree of freedom, and can exhibit an apparent irreversibility even in such a simple system. The phase complexities of localized wavefunction can have a possibility to occur the irreversibility in this model. The details will be reported elsewhere. The author thanks Prof. K.Ikeda for stimulating discussions.

References

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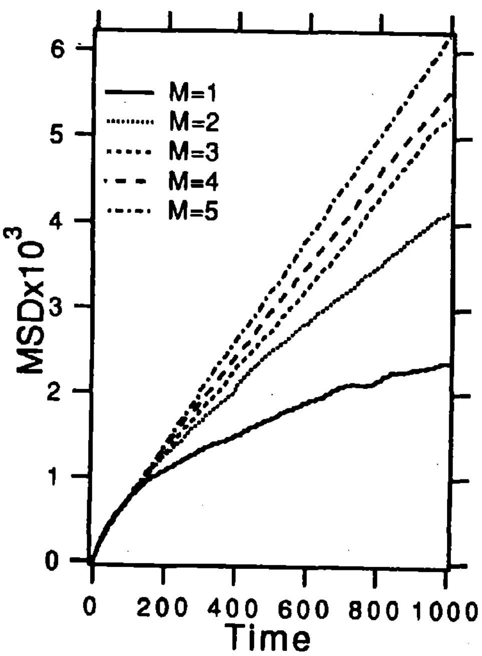

Fig.1. The MSD for the case of W=0.9, ϵ_i=0.5 with multiple colors (M=1,..., 5).

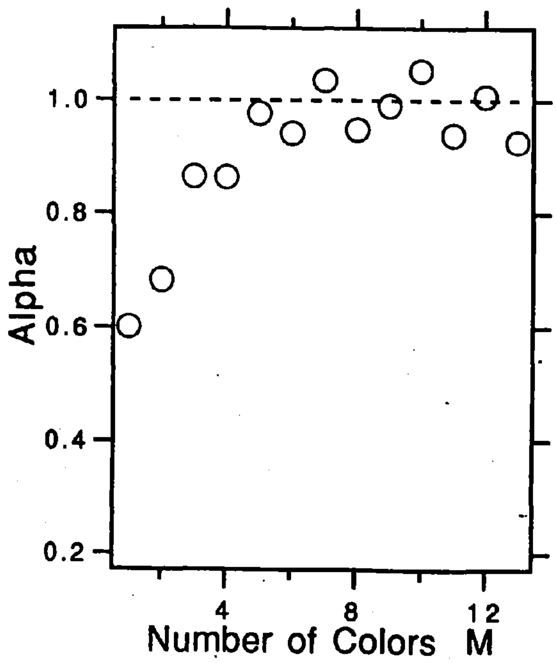

Fig.2. The exponent α estimated by least square method for ln-ln plot of MSD.